METHOD AND APPARATUS FOR ASSESSING THE VISIBILITY OF DIFFERENCES BETWEEN TWO IMAGE SEQUENCES

This application claims the benefit of U.S. Provisional Applications No. 60/014,332 filed Mar. 29, 1996, No. 60/014,688 filed Apr. 2, 1996, and No. 60/014,333 filed Mar. 29, 1996.

The present invention relates to an apparatus and concomitant method for evaluating and improving the performance of imaging systems. More particularly, this invention relates to a method and apparatus that assesses the visibility of differences between two image sequences.

BACKGROUND OF THE INVENTION

Designers of imaging systems often assess the performance of their designs in terms of physical parameters such as contrast, resolution and bit-rate efficiency in compression/decompression (codec) processes. While these parameters can be easily measured, they may not be accurate gauges for evaluating performance. The reason is that end users of imaging systems are generally more concerned with the subjective visual performance such as the visibility of artifacts or distortions and in some cases, the enhancement of these image features which may reveal information such as the existence of a tumor in an image, e.g., a MRI (Magnetic Resonance Imaging) image or a CAT (Computer-Assisted Tomography) scan image.

For example, an input image can be processed using two different codec algorithms to produce two different codec images. If the measure of codec image fidelity is based purely on parameters such as performing mean squared error (MSE) calculations on both codec images without considering the psychophysical properties of human vision, the codec image with a lower MSE value may actually contain more noticeable distortions than that of a codec image with a higher MSE value.

Over the years, various human visual performance models have been used to improve imaging system design. One model (known as the Carlson and Cohen model) decomposes an input image by partitioning its one-dimensional power spectrum into a number of discrete adjacent frequency bands. The integral of the amplitude values within each band is then subjected to a static non-linearity that is accelerating for small input values and compressive for large values. Changes in the output of this process from one member of a pair of images to the other provide a simple perceptual measure of the visibility of differences between the two images.

A similar method is the square root integral model (SQRI). In this model, the separate frequency-selective bands are replaced by a single integral over spatial frequencies, based on the ratio between the modulation transfer function of the display and an arithmetic approximation to the contrast sensitivity function of the human observer. Although the SQRI has been successfully applied to a number of different display evaluation problems, this model and other basic psychophysics models are spatially one-dimensional. Namely, these models predict sensitivity to spatial variation in one dimension only.

Therefore, a need exists in the art for a method and apparatus for assessing the effects of physical parameters on the subjective visual performance of an imaging system. Specifically, a need exists for a method and apparatus for assessing the visibility of differences between two sequences of time-varying visual images.

SUMMARY OF THE INVENTION

The present invention is a method and apparatus for assessing the visibility of differences between two input image sequences. The apparatus comprises a visual discrimination measure having a retinal sampling section, a plurality of temporal filters and a spatial discrimination section.

The retinal sampling section applies a plurality of transformations to the input image sequences for simulating the image-processing properties of human vision. The retinal sampling section converts the input images to retinal images. Furthermore, if chrominance components are present in the input images, additional transformations are applied to the input image sequences for assessing the visibility of differences in the chrominance components.

The temporal filters then separate each of the sequences of retinal images into two temporal channels producing a lowpass temporal response and a bandpass temporal response, thereby producing a total of four temporal responses (if chrominance components are addressed in the input image sequence). Next, the spatial discrimination section applies spatial processing to the images to produce an image metric which reveals the visibility of differences between the two input image sequences.

BRIEF DESCRIPTION OF THE DRAWINGS

The teachings of the present invention can be readily understood by considering the following detailed description in conjunction with the accompanying drawings, in which:

FIG. **1** illustrates a block diagram of a signal processing system of the present invention;

FIG. **2** illustrates a simplified block diagram of the structure of the visual discrimination measure;

FIG. **3** illustrates a detailed block diagram of the structure of the visual discrimination measure;

FIG. **4** illustrates a block diagram of the retinal sampling section of the visual discrimination measure;

FIG. **5** illustrates an example of a fixed value border;

FIG. **6** illustrates an example of an edge controlled border;

FIG. **7** illustrates a flowchart of a method for generating a contrast pyramid;

FIG. **8** illustrates a flowchart of a method for implementing the color adjunct embodiments of the visual discrimination;

FIG. **9** illustrates a block diagram of the oriented filters of the present invention;

FIG. **10** illustrates a flowchart of a method for generating an image metric; and

FIG. **11** illustrates a flowchart of a method for assessing the visibility of differences between two input image sequences.

To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures.

DETAILED DESCRIPTION

FIG. **1** depicts a signal processing system **100** that utilizes the present invention. The signal processing system consists of a signal receiving section **130**, a signal processing section **110** and input/output devices **120**.

Signal receiving section **130** serves to receive input data signals, such as sequences of images from imaging devices.